THE MARY INGRAHAM BUNTING INSTITUTE
OF RADCLIFFE COLLEGE

TECHNICAL REPORT
ONR GRANT #N00014-89-J-3112
SCIENCE SCHOLARS PROGRAM
7/1/93-6/30/94

Prepared by:
Florence C. Ladd, Principal Investigator
Renny Harrigan, Project Director

This technical report for the 1994 Science Scholars Program at the Bunting Institute of Radcliffe College will describe the program and fiscal year 1994 participants; offer the scholars' evaluations of their program year; describe events of the year; discuss issues involved with the program; and conclude with a description of the selection process for the 1994 ONR Science Scholars. Appendices contain scholars' publications, their year-end reports to ONR, and other pertinent materials.

1994 Program

Background of the Program

The Office of Naval Research funded the Science Scholars Program at the Bunting Institute of Radcliffe College in 1980 to provide a year of support to enhance the professional careers of women scientists in a range of fields. The program supported eight scholars with eight stipends in fiscal year 1994. (Two more unfunded scientists were part of the Bunting Institute cohort as well.) Each scholar received a stipend of $31,300 plus $3,000 in research expenses, along with an office at the Bunting Institute to support her laboratory work in a Boston-area university. Each of the 1994 scholars was laboratory-based, and all of the scholars spent from July 1, 1993 to June 30, 1994 at Bunting. Two were funded a second time, Lisa Vawter for a second full year and Constance Royden who had had a half year of funding in the 1992-93 cycle.

The 1994 scholars, along with their home affiliations, included:

Rama Bansil, Department of Physics, Boston University, "Biophysical Studies of Mucin Gels"

Susan Circone, Department of Earth and Planetary Sciences, Harvard University, "Compressibility of Titanium-Bearing

Liquid Silicates"

Rosanne Di Stefano, Department of Physics, New York Institute of Technology and Visiting Scientist, Massachusetts Institute of Technology, "Studies in Theoretical Astrophysics"

Florence Lin, Research Associate, Department of Mathematics, University of California Berkeley, "Geometric, Numerical, and Nonlinear Dynamical Systems Studies in Molecular Dynamics"

Lauren Rose, Department of Mathematics, Wellesley College, "Algebraic Combinatorics and Multivariate Splines"

Constance Royden, Research Associate in Neural Science, Media Lab, Massachusetts Institute of Technology, "Human Perception of Motion Transparency: Computational and Psychophysical Studies"

Leila Schneps, Centre National de Recherche Scientifique, Faculte des Sciences de Besançon, "The Absolute Galois Group $Gal(\bar{\mathbb{Q}}/\mathbb{Q})$ and Modular Tower"

Lisa Vawter, Museum of Comparative Zoology Lab, Harvard University, "Evolutionary Genetics of Termites"

Scholars' Evaluations of the Bunting Year

The evaluations of the Science Scholars demonstrate that the fellowship year offers them strong professional opportunities. As a group, they uniformly found the year to be successful and rewarding. The money provided by the fellowship made an enormous difference in enhancing the career and research opportunities of several fellows. In addition, they cited several particular benefits provided by the fellowship at the Bunting Institute.

1. Resources to learn new techniques. Zoologist Lisa Vawter, neural scientist Constance Royden, and chemical physicist Florence Lin are changing the direction of their research, the latter two in substantial ways. Vawter, while remaining in zoology, changed her focus from phylogenetic to population genetic zoology. The latter, which has far more practical applications than the former, is also more fundable. Royden added computer modeling to the psychophysical analysis of how people judge their heading in the presence of moving objects. Trained as a molecular biologist for her Ph.D. to examine genes that affect the nervous system, Royden added pyschophysical techniques to her repertoire during her first postdoc, and began at the Bunting to develop computer techniques which combine with the psychophysical ones. Florence Lin, whose Ph.D. in Chemical Physics was followed

by a second M.A. in Mathematics, used the year to solve mathematically the practically-interesting problems which others have not solved so elegantly, if at all.

2. Valuable time to write. Many Science Scholars have juggled the heavy demands of teaching, administrative work and research for several years, and appreciate the opportunity to devote themselves fully to their research. Rama Bansil at Boston University found that the year, "unfettered by the usual duties of a faculty member" " has allowed [her] to focus on a new research problem in the area of biophysics."

As a senior faculty member at a large university, Bansil's daily life there is different from that of Lauren Rose, a junior faculty member at a small undergraduate college (Wellesley), where the teaching is combined with a heavy workload of both advising and administrative duties. Rose, however, adds "During the course of the year I developed a stronger sense of myself as a mathematician than I had before. I had always seen myself as a teacher of mathematics, but only a visitor in the realm of research."

3. Opportunities for professional contacts. Because the fellowship requires affiliation with a Boston-area laboratory, scholars use the opportunity to meet and work with new colleagues. This opportunity benefits not only scholars who are new to Boston, but local scientists who are shifting their work as well.

Lauren Rose (mathematician at Welleseley) spent the year as a visiting scholar at MIT where she had easy access to that university's resources and to the lively group of algebraic combinatorics researchers in the mathematics department.

Constance Royden established a very productive working relationship with Professor Ellen Hildreth in Computer Science at Wellesley which also allowed her to combine the psychophysical with the computational aspects of her work for the first time.

Florence Lin who was applying mathematical methods to chemical physics, gained national exposure in mathematics through her work with a Harvard group headed by Donald G.M. Anderson.

4. Enhanced job-hunting and grants opportunities. This year, many of the Science Scholars successfully sought to strengthen their research positions, rather than seek new positions, perhaps because so many of them were involved in carving out new areas of research which were, in some cases, cross-disciplinary (Di Stefano, Royden and Lin). Several commented that the financial support as well as the prestige of the fellowship improved their job-hunting success equally as much as the contact with other professionals in their field. Florence Lin moved on to the Mathematics Department at USC in Los Angeles. Rosanne Di Stefano was awarded a two-year NSF Visiting Professorship for Women through Harvard University at the

Smithsonian Center for Astrophysics. Constance Royden continues her work with NSF support in the Computer Science Department at Wellesley College.

5. Interactions with other Bunting fellows. Because the Bunting Institute is a multidisciplinary center for advanced studies, the Science Scholars enjoy the opportunity to work with scholars and professionals in a wide variety of fields. These interactions provide enormous intellectual support to the scholars. Geologist Circone describes best what is generally felt by all:

> In addition to the important progress that I have made in my research, the funding provided through ONR has given me the unique opportunity to interact with a group of remarkable women. They represent a diversity in interests, age and backgrounds that I have not encountered amongst my peers in science. What I have gained in knowing them is at least as important and significant to the research that I have accomplished. It is an opportunity unique to the Bunting Institute and one not afforded by any other fellowship program. It has been a privilege to be here this past year.

Another corollary to the Bunting experience of gathering remarkable women together is expressed by mathematician Lauren Rose when she comments on what she considers the "unique opportunity ...to introduce a group of women scholars in all fields to the fascinating world of pure mathematics." The reciprocity of the relationships with specialists and non-specialists alike is manifest.

In addition, the Science Scholars continued a regular study group on Gender and Science that was created by last year's Bunting Science Scholars. Approximately every three weeks this group -- composed of past and present Science Scholars, local scientists, and other interested members -- convened to read and discuss material related to the practice of science.

Events and Highlights of the 1993-94 Fellowship Year

1. Renewal of the ONR grant. We are very pleased to report that the Office of Naval Research renewed the grant in support of the Science Scholars at the Bunting Institute of Radcliffe College for five years. We will be able to fund the program at a total of $2,015,000 through the 1998-99 fiscal year. We also changed the ONR fiscal year for the grant which now begins with Radcliffe's fiscal year on July 1.

2. Colloquia and presentations. Scholars are required to present their work-in-progress at a public colloquium sometime during the fellowship year. The presentations are followed by a

less formal and less technical brown bag lunch discussion at the Bunting Institute the following day. Seven of the scholars also presented their technical work in scientific lecture series, poster sessions or professional conferences. The dates and titles of all these talks are listed in Appendix C.

3. Gender and Science discussion group. This study group, created in 1989-90, provides an excellent opportunity for scientists in a range of disciplines to discuss issues relating to science, gender, and society. The group met every two or three weeks, choosing together works of interest to all. The group takes advantage of the multidisciplinary community of the Bunting Institute, often inviting policy practitioners and historians of science to join the discussion.

Selection for the 1994 Program

Applicant Pool

Bunting received 26 eligible applications for the 1993-94 Science Scholars fellowships. Applications were reviewed by first-stage readers, scientists who are specialists in the candidate's field. Based on those reviews, 24 of the 26 applications were advanced to the next round. As in the past, this high ratio of successful applications testifies to the quality of the initial applications.

Selection Procedures

An 8-member selection committee met on March 5, 1993 to judge the applications and recommend eight candidates for the 1993-94 fellowship awards. The committee members, who represented the disciplines of the applicants, are senior scientists from academic departments at Harvard University, the Massachusetts Institute of Technology, Tufts Medical School and Wellesley College. Their names are listed in Appendix E. After a morning of deliberations, the committee recommended eight candidates for the Science Scholar positions, five alternates and one for the Bunting Fellowship who, because of her British citizenship, was not eligible to compete as a Science Scholar. Of this pool, six of the original candidates became Science Scholars, and two moved up from the alternate pool.

Future Plans of 1994 Scholars

Many of the 1994 scholars experienced good success in finding new academic and research positions. Three of the scholars returned to tenured or tenure-track positions; three were funded in additional post-doc years; one stayed on at the lab she came to work in as a Bunting Science Scholar.

Rama Bansil returned to Boston University and was promoted to Full Professor. The year enabled her to focus on new research problems in the area of biophysics, to learn about mucins, and to make valuable connections between her work on synthetic polymer gels and more complex biological gels.

Susan Circone plans to finish up work at Harvard and move to California during the 1994-95 year where she will establish herself.

Rosanne DiStefano finished her second year as a Science Scholar at the Bunting in astrophysics. During the second year, she moved from MIT to Harvard. She applied for two major grants, both of which were funded: a NASA theory program written with Saul Rappaport of MIT, and an NSF Visiting Professorship for Women which allows her to spend two more years at Harvard as a faculty member at the Smithsonian Center for Astrophysics.

Florence Lin received an NSF Research Planning Grant for the project, "Geometric and Numerical Methods for Dynamical Systems" at the Department of Mathematics, USC Los Angeles.

Constance Royden has received another year of funding from NSF, working with Ellen Hildreth at Wellesley College in the Department of Computer Science.

Lisa Vawter changed the direction of her research on termites from phylogenetic to population genetic and has stayed on at the Museum of Comparative Zoology in the lab of Dr. Naomi Pierce, an earlier Science Scholar.

Lauren Rose and **Leila Schneps** returned to their institutions.

List of Appendices

The Mary Ingraham Bunting Institute of Radcliffe College
1993–94 Fellows

PAULA L. AYMER
Fellow (Sociology)
Tufts University
Capitalist Incursions and Intra-Caribbean Migration: A Case Study of Eastern Caribbean Migrant Domestics in Aruba

RAMA BANSIL
Science Scholar (Physics)
Boston University
Biophysical Studies of Mucin

ELLA L.J. EDMONDSON BELL
Massachusetts Institute of Technology
STELLA M. NKOMO
University of North Carolina at Charlotte
Radcliffe Visitors-In-Residence
(Management and Organizational Behavior)
Life Journeys of Women in Corporations

KAROL BENNETT
Evelyn Green Davis Fellow (Vocal Performance)
The Rivers School of Music
Vital Vocal Vistas

SARAH MAUSOLFF BUEL
Evelyn Green Davis Fellow (Law)
Suffolk County District Attorney's Office
Family Violence: The Crisis and Innovative Responses

ELIZABETH BUSSIERE
Fellow (Political Science)
University of Massachusetts at Boston
The American Jury and the Decline of Popular Justice

MARIA MAGDALENA CAMPOS–PONS
Bunting Fellow (Visual Arts)
Independent Artist
History of People Who Were Not Heroes: Growing Up in a Slave Barrack

HELEN HARDEN CHENUT
Fellow (History)
Mount Holyoke College
Gender, Politics, and Culture in a French Textile Town, Troyes, 1880–1939

SUSAN CIRCONE
Science Scholar (Geology)
Harvard University
Compressibility of Titanium–Bearing Silicate Liquids

M.E. KROPP DAKUBU
Fellow (Linguistics)
University of Ghana
Crossing the Bar: Language, History, and Ethnicity in a West African City

E. VIRGINIA DEMOS
Marian Cabot Putnam Fellow (Psychology)
Harvard Medical School and Beth Israel Hospital
The Psychic Life of the Infant

DENISE DILNOT
Fellow (Visual Arts)
Independent Artist
The Underside of Things

ROSANNE DI STEFANO
Science Scholar (Astrophysics)
New York Institute of Technology
Studies in Theoretical Astrophysics

ROBIN FLEMING
Bunting Fellow (Medieval History)
Boston College
Law and Society in Eleventh–Century England

ROSE E. FRISCH
Fellow (Reproductive Biology)
Harvard School of Public Health
Energy Resources, Puberty, and Fertility

BETH ANN GOLDRING
Hermon Dunlap Smith Fellow (Peace Studies)
Palestinian Federation of Women's Action Committees
Developing Context-Specific Human Rights Work

BARBARA HILDT
Radcliffe Fellow in Public Policy (Public Policy)
The Medical Foundation, Boston
The New Politics of Inclusion: Transforming Power, Creating Change

ROBIN KILSON
Bunting Fellow (Black Women's Studies)
Massachusetts Institute of Technology
Passing for Ariel: The History of Black Women Doctorates in American Academia, 1921–1991

MODUPE LABODE
Berkshire Summer Fellow (History)
Iowa State University
U.S. Women's Missionary Societies and Africa, 1880–1920: An Exploration of Race, Gender, and Nationality

MARY LASSEN
Bunting Fellow (Social Policy)
Committee for Boston Public Housing
Empowering Approaches to Service Delivery and Leadership Development in Public Housing Communities

FLORENCE J. LIN
Science Scholar (Applied Mathematics)
University of California at Berkeley
Geometric, Numerical, and Nonlinear Dynamical Systems Studies in Molecular Dynamics

PATRICIA CLEARY MILLER
Radcliffe Alumna Fellow (Poetry)
Rockhurst College
Without Ice Axes

DEBRA C. MINKOFF
Fellow (Sociology)
Yale University
Associating for a Change: The Shaping of American Social Action

VIRGINIA NEWES
Fellow (Musicology)
Eastman School of Music
Questions of Genre in the French Secular Song, ca. 1350–1420

HANNA PAPANEK
Fellow (Nonfiction)
Boston University
In Search of Exile

ANN PATCHETT
Bunting Fellow (Fiction and Nonfiction)
Independent Writer
Taft

SUSAN POWER
Bunting Fellow (Fiction)
University of Iowa
The Grass Dancer, a novel

LAUREN L. ROSE
Science Scholar (Mathematics)
Wellesley College
Algebraic Combinatorics and Multivariate Splines

CONSTANCE ROYDEN
Science Scholar (Computational Neuroscience)
Wellesley College
Human Heading Perception: Computational and Psychophysical Studies

LEILA CYNTHIA SCHNEPS
Science Scholar (Mathematics)
Centre National de la Recherche Scientifique, France
The Absolute Galois Group from a Geometric Viewpoint

LESLIE C. SHAW
Fellow (Anthropology and Archaeology)
University of Massachusetts at Boston
The Emergence of Inequality in the Maya Lowlands

PATRICIA L. SIPE
Fellow (Mathematics)
Smith College
DES and Risk: Subjectivity in Statistical Methods for Public Health

SANDRA STEINGRABER
Evelyn Green Davis Fellow (Poetry and Biology)
Columbia College, Chicago
Post–Diagnosis: Ecological Poetry

RITSUKO TAHO
Bunting Fellow (Visual Arts)
Massachusetts Institute of Technology
Transformation: Language of Nature

SUSAN L. TANANBAUM
Fellow (British and Jewish History)
Bowdoin College
Making "Worthy Citizens": The Anglicization of Immigrant Women and Children in the Jewish East End, 1880–1939

JUDITH THOMPSON
Peace Fellow (Peace Studies)
Children of War, Inc.
Rising From the Ashes: Building a Community of Hope

AMY C. TISHELMAN
Children's Hospital–Radcliffe College Joint Fellow in Family Violence (Clinical Psychology)
Children's Hospital and Harvard Medical School
Systems Analysis in Family Violence: Exploring the Fundamental Conflicts

JESSICA TREADWAY
Fellow (Fiction)
Independent Writer
Shirley Wants Her Nickel Back, a novel

LISA VAWTER
Science Scholar (Molecular Evolution)
Harvard University
Evolutionary Genetics of Termites

MAXINE YALOVITZ–BLANKENSHIP
Fellow (Visual Arts)
Independent Artist
Painting an Epic Poem

ABBY ZANGER
Fellow (French Literature)
Harvard University
Exploding Symbols: Imagining the Queen in the Marriage of Louis XIV

APPENDIX B.

BRIEF RESUMES OF 1993-94 SCHOLARS

note: the resumes are culled from the information on the application forms, therefore from the fall of 1992. Exception: Lin (spring of 1994) and Royden (spring 1995)

PII Redacted

Rama Bansil

[redacted]

Physics Department
Boston University
(617-353-2969 (W)

Education

University of Rochester	*Physics*		*Ph.D. 1975*
University of Delhi	*Physics*		*M.Sc. 1969*
University of Delhi	*Physics*	*(Honors)*	*B.Sc. 1967*

Professional Experience

Boston University	*Associate Professor of Physics* *Assistant Professor of Physiology*	*1976 - present*
Massachusetts Inst. of Technology	*Research Associate,* *Health Sciences & Technology*	*1975-76*
Harvard University	*Vinton Hayes Fellow,* *Applied Physics*	*1974-75*

Publications and Presentations

I. Nishio, J.C. Reina and R. Bansil, "Quasi-elastic light scattering study of the movement of particles in gels," Phy,. Rev. Latt. 59,684 (1986)

R. Bansil, S. Pajevic and C. Konak, "Diffusion of polystyrene in gels," Macromolecules 23 3380 (1990).

J. Lal and R. Bansil, "Light Scattering Study of Kinetics of Spiondal Decomposition in a Polymer Solution," Macromolecule 24 290 (1991).

K.R. Bashkar, D. Gong, R. Bansil, S. Pajevic, J.A. Hamilton, B.S. Turner and J.T. Lal, "Profound Increase in Viscosity and Aggregation of Pig Gastric Mucin at Low pH," Am. J. of Physiology" Gastronenterology and Liver Physiology, G827 (1001).

R. Bansil, J.Lal and B.Carvalho, "Effects of gelatin on kinetics of spinodal decomposition in gelatin," Polymer, 33 2961 (1992).

INVITED TALK" 34th IUPAC International Symposium on Macromolecules, Prague, 1992.

Honors

Vinton Hayes Fellowship, Harvard University for Postdoctoral Research	*19974-5*
Whitaker Health Sciences Fund Award (MIT -BU collaboration)	*1978-79*
American Cancer Society Junior Faculty Award	*1979-82*
Member, NIH Study Section and Site Visit Team,	*1981-82*
Member, NSF Review Panel, Presidential Young Investigator Award Program,	*1991*

Curriculum Vitae

SUSAN CIRCONE

The Bunting Institute
34 Concord Ave.
Radcliffe College
Cambridge, MA 02138

Tel.: (617)495-8212

Dept. of Earth and Planetary Sciences
Harvard University
20 Oxford St.
Cambridge, MA 02138

Tel.: (617) 496-3749

[redacted]

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EDUCATION

Ph.D.	Geological Sciences, Princeton University, June 1991. Dissertation title: $^{[4,6]}$Al substitution in phlogopite: compositional, structural and thermochemical properties of trioctahedral micas in the phlogopite-eastonite solid solution.
M.A.	Geological Sciences, Princeton University, June 1986.
----	Geological Sciences, Arizona State University, 1984/85.
B.S.	Geological Sciences, *Cum laude*, University of Vermont, May 1982.

PROFESSIONAL MEMBERSHIPS AND SOCIETIES

Phi Beta Kappa, Sigma Xi, American Geophysical Union, Mineralogical Society of America

PROFESSIONAL

1993-present	Science Scholar Fellow, Bunting Institute, Radcliffe College.
1991-1993	Postdoctoral Research Fellow, Harvard University.
1985-1989	Research and Teaching Assistant, Princeton University.
1984-1985	Research and Teaching Assistant, Arizona State University.
1981	Laboratory Assistant, University of Vermont.

RESEARCH

Experimental petrology
Thermodynamics
High-pressure materials science

Related Research Publications

Manuscripts

Circone, S., and Agee, C.B. (1994) Liquid-liquid immiscibility in the system TiO_2-SiO_2 at 3.0 GPa. In preparation.

Circone, S. and Navrotsky, A., Substitution of $^{[6,4]}Al$ in phlogopite: high temperature solution calorimetry, heat capacities, and thermodynamic properties of the phlogopite-eastonite join, *Am. Mineral.*, 77, 1191-1205 (1992).

Circone, S., Navrotsky, A., Kirkpatrick, R.J., and Graham, C.M., Substitution of $^{[6,4]}Al$ in phlogopite: mica characterization, unit-cell variation, ^{27}Al and ^{29}Si MAS-NMR spectroscopy, and Al-Si distribution in the tetrahedral sheet, *Am. Mineral.*, 76, 1485-1501 (1991).

Clemens, J. D., Circone, S., Navrotsky, A., McMillan, P. F., Smith, B. K., and Wall, V. J., Phlogopite: high temperature solution calorimetry, thermodynamic properties, Al-Si and stacking disorder, and phase equilibria, *Geochim. Cosmochim. Acta*, 51, 2569-2578 (1987).

Navrotsky, A., Rapp, R.P., Smelik, E., Burnley, P., Circone, S., Chai, L., Bose, K., and Westrich, H.R. (1993) The behavior of water and carbon dioxide in high temperature lead borate solution calorimetry of volatile-bearing phases. Submitted 11/93 to American Mineralogist.

Abstracts

Circone, S. and Agee, C.B., Phase equilibria in the system SiO_2-TiO_2 at high pressure: Evidence for pressure-induced silicon coordination change. EOS 73, 603 (1992).

Circone, S. and Navrotsky, A., Thermochemistry of the phlogopite-eastonite join. EOS 71,1648-1649 (1990).

Circone, S., Navrotsky, A., Kirkpatrick, R.J., Aluminum substitution in MgAl-biotites: Synthesis, structure, ^{29}Si and ^{27}Al MAS-NMR spectroscopy. EOS 69, 501 (1988).

Curriculum Vitae

Rosanne DiStefano

Physics Department
New York Institute of Technology
Central Islip Campus
Central Islip, N.Y. 11722
(516) 348-3067/3047
Home: (516) 286-7404

Physics Department
Massachusetts Institute of Technology
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E-MAIL:
RD@SPACE.MIT.EDU

Present Positions: Associate Professor of Physics
New York Institute of Technology

Visiting Scientist
Physics Department
Massachusetts Institute of Technology

Education

1982	S.U.N.Y. at Stony Brook	Ph.D. Physics
1976	Columbia University	M.A. Physics
1973	Queens College City University of New York	B.A. *magna cum laude* Physics

Awards and Honors

1973	Physics Prize	Queens College
1986	President	Association of Women in Science, Long Island Chapter
1990	Grant-in-Aid	American Institute of Physics

Papers and Preprints

Notes on the Conceptual Development of Supersymmetry, to be published in the book History of Modern Gauge Theories, edited by M. Dresden (World Scientific, 1990).

Disappearance of the auxiliary fields in a canonical formulation of supersymmetry, Phys. Lett. **B192**, 130 (1987).

On the canonical formulation of supersymmetric Yang-mills theories (with M. Kruezer, A. Rebhan), Mod. Phys. Lett. **A2** (1987).

Hamiltonian-Dirac formulation of supersymmetric Yang-Mills theories (with M. Kruezer, A. Rebhan), Proceedings of the XXVI Int. Universitatswochen für Kernphysik (1987).

Modification of Dirac's methods of Hamiltonian analysis for constrained systems, Phys. Rev. **D27**, 1752 (1983).

New approach to the first-order canonical formulation of gravitation: application to Einstein-Cartan-Sciama-Kibble theory (with Richard T. Rauch), Phys. Rev. **D26**, 1242 (1982).

Canonical construction of supersymmetric theories and algebras, Stony Brook Report ITP-SB-87-81.

Closure of the supersymmetry algebra without auxiliary fields and a canonical formulation of superfields, Stony Brook Report ITP-SB-85-9.

Modified Hamiltonian analysis for non-differentiable Hamiltonians, Stony Brook Report ITP-SB-81-37.

Florence J. Lin

PII Redacted

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Department of Mathematics
University of California
Berkeley, CA 94720

Education

1986-1988	University of California, M.A. Mathematics
1976-1984	Harvard University, Ph.D. Chemical Physics
1976-1984	Harvard University, A.M. Physics
1972-1976	University of California, Berkeley, A.B. Mathematics and Chemistry

Professional Experience

1990-present	University of California, Berkeley Visiting Scholar (Research Associate)
Fall, 1992	Holy Names College Lecturer
1988-1990	Brookhaven National Laboratory Senior Research Associate
1986-1988	University of California, Berkeley Graduate Student
1984-1986	Harvard-Smithsonian Center for Astrophysics Physicist
1984-1986	Harvard University Associate of the Harvard College Observatory

Professional Accomplishments

F.J. Lin and J.E. Marsdne, Symplectic reduction and topology for applications in classical molecular dynamics, *J. Math. Phys.* **33**, 1281-1294 (1992).

F.J. Lin and J.E. Marsden, "Geometric mechanics, optimal control, and molecular dynamics," Workshop on the Control of Molecular Systems , The Fields Institute for Research in Mathematical Sciences, Waterloo, Ontario, Canada, presented June 3, 1992.

F.J. Lin and J.E. Marsden, "Geometric mechanics and molecular reaction dynamics," XIVth International Symposium on Molecular Beams, Asilomar Conference Grounds, Pacific Grove, California, presented June 9, 1992.

F.J. Lin, "Geometric mechanics and molecular dynamics, "Differential Geometry Seminar, Department of Mathematics, University of California, Berkeley, presented November 1, 1991.

Honors and Awards

Invited Speaker, Workshop on the Control of Molecular Systems, The Fields Institute for Research in Mathematical Sciences, Waterloo, Ontario, Canada; June 1-3, 1992

Poster presentation, XIVth International Symposium on Molecular Beams, Asilomar Conference Grounds, Pacific Grove, CA; June 7-12, 1992

Participant, Dynamics, Competion, and Neural Networks, Dynamical Systems Institute, Department of Mathematics, Boston University, Boston, MA; Junly 26-30, 1992

PII Redacted

Lauren Rose

[redacted]

Mathematics Department
Wellesley College
Wellesley, MA 02181
617-283-3114 (W)

Education

Cornell University	1982-1985	M.A., Mathematics
Cornell University	1985- 1988	Ph.D., Mathematics
Tufts University	1978-1982	B.A., Mathematics

Professional Experience

Wellesley College	1990 to present	Assistant Professor of Math
Ohio State University	1987 to 1990	Assistant Professor of Math

Publications

1992 "Modules of Polynomials and their Freeness," Mathematische Zeitschrift

1991 "Free Resolution of the Module of Logarithmic Foms of a Generic Arrangement," Journal of Algebra

1990 "Hilbert Polynomials and Geometric Lattices, Advances in Mathematics

1989 "Grobner Basis Methods for Multivariate Splines"

1990 "A Dimension Series for Multivariate Splines," Discrete and Computational Geometry,

Honors and Awards

NSF Research Planning Grant		June 1989- May 1990
Hutchinson Fellowship	Cornell University	1985-86
Ralph S. Kaye Memorial Prize	Tufts University	May 1986
Alpha Xi Delta Prize Scholarship	Tufts University	May 1986

CONSTANCE S. ROYDEN
Curriculum Vitae--March, 1995

PII Redacted

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Work:
Computer Science Dept.
Wellesley College
Wellesley, MA 02181
(617) 283 - 2743

EDUCATION:

6/80 B.S. Biology and Engineering, California Institute of Technology, Pasadena, California.

6/88 Ph.D. Neuroscience, University of California, San Francisco, California.

RESEARCH EXPERIENCE:

6/79-6/80 Electrophysiology of Primate Visual Cortex
Department of Biology, California Institute of Technology. Advisor: Prof. John Allman

6/81-9/81 Visual Psychophysics Research
Department of Biology, California Institute of Technology. Advisor: Prof. John Allman

9/81-6/88 Graduate Research: Molecular Analysis of tko, a behavioral mutant of Drosophila melanogaster. Neuroscience Program, University of California, San Francisco.
Thesis Advisor: Prof. Lily Jan

9/88-5/90 Postdoctoral Research: A biologically plausible model of optic flow perception: A computational and psychophysical approach.
School of Optometry, University of California, Berkeley. Advisor: Prof. Martin Banks

12/90-8/92 Postdoctoral Research: Computational and psychophysical studies of Human Perception of Motion Transparency.
Media Lab, Massachusetts Institute of Technology. Advisor: Prof. Edward Adelson

9/92-present Postdoctoral Research: Heading perception in the presence of moving objects.
Dept. of Computer Science, Wellesley College. Advisor: Prof. Ellen Hildreth

HONORS AND FELLOWSHIPS:

Carnation Prize Scholarships, 1978 - 1979 and 1979 - 1980
Election to Tau Beta Pi (Engineering Honor Society), 1979
B.S. with Honor from California Institute of Technology, 1980
Thomas J. Watson Fellowship, 1980-1981
National Science Foundation Fellowship, 1981 - 1984
UCSF Chancellor's Fellowship, 1984, declined
Fife Fellowship, 1984 - 1985
UC Graduate Opportunity Fellowship, 1986 - 1987
Life Sciences Research Foundation Postdoctoral Fellowship, 1988 - 1992
Fairchild Fellowship, 1992
Mary Ingraham Bunting Science Scholars Fellowship, 1992-1993 & 1993-1994

GRANTS:

Principal Investigator on National Science Foundation grant to E.C. Hildreth and C.S. Royden. "The analysis of 3-D motion for visually-guided navigation. April, 1994 - March, 1997.

INVITED TALKS:

Center for Neuroscience Seminar, University of California at Davis, CA. April 17, 1993.
Computer Science Colloquium, Wellesley College, Wellesley, MA. April 28, 1993.
Center for Brain and Behavior Seminar, Harvard University, Cambridge, MA. May 14, 1993.
Bunting Institute Colloquium, Cambridge, MA. May 19, 1993.
Bunting Institute Colloquium, Cambridge, MA. November 17, 1993.
Woods Hole Workshop in Computational Neuroscience, Woods Hole, MA. August 25, 1994.
Caltech Computation and Neural Systems Seminar, Pasadena, CA, January 27, 1995.

PROFESSIONAL SOCIETIES:

National Society for Neuroscience
Society for Research in Vision and Ophthalmology

PUBLICATIONS:
PAPERS:

Royden, C.S. and Hildreth, E.C. (1995) Human Heading Perception in the presence of moving objects. In Preparation.

Hildreth, E.C. and Royden, C.S. (1995) Recovering heading in the presence of moving objects. Proceedings of the International Workshop on Computational Vision and Parallel Processing, Islamabad, Pakistan: 111 - 120.

Royden, C.S. (1994) Analysis of misperceived observer motion during simulated eye rotations. Vision Research 34: 3215 - 3222.

Royden, C.S., Crowell, J.A., and Banks, M.S. (1994) Estimating heading during eye movements. Vision Research 34: 3197 - 3214.

Royden, C.S. (1994) In defense of "Gravity as a monocular cue for perception of absolute distance and/or absolute size". Perception 23: 733 - 735.

Hildreth, E.C. and Royden C.S. (1994) Models of motion perception. In: Arbib, M.A. (Ed.) The handbook of brain theory and neural networks. Cambridge: The MIT Press. In Press.

Royden, C.S., Banks, M.S., and Crowell, J.A. (1992) The perception of heading during eye movements. Nature 360: 583-585.

Royden, C.S., Crowell, J.A., and Banks, M.S. (1992) Mathematical analysis of motion-opponent mechanisms used in the determination of heading and depth. In Preparation.

Watson, J.S., Banks, M.S., von Hofsten, C. and Royden, C.S. (1992) Gravity as a cue for perception of absolute distance and/or absolute size. Perception 21: 69 - 76.

Royden, C.S., Baker, J.F., and Allman, J.M. (1988) Perceptions of depth elicited by occluded and shearing motions of random dots. Perception 17: 289 - 296.

Royden, C.S., Pirrotta, V. and Jan, L.Y. (1987). The tko locus, site of a behavioral mutation in Drosophila melanogaster, codes for a protein homologous to prokaryotic ribosomal protein S12. Cell 51: 165 - 173.

ABSTRACTS:

Royden, C.S. and Hildreth, E.C. (1995) The effect of attention on judgment of heading and 3D object motion. Annual Meeting Abstract Issue, Assoc. for Res. in Vision and Ophth. 36: S829.

Royden, C.S. and Hildreth, E.C. (1994) The effects of moving objects on heading perception. Annual Meeting Abstract Issue, Assoc. for Res. in Vision and Ophth. 35: 1999.

Royden, C.S., Laudeman, I.V., Crowell, J.A., and Banks, M.S. (1992) The influence of eye movements on heading judgments. Annual Meeting Abstract Issue, Assoc. for Res. in Vision and Ophth. 33: 1051.

Crowell, J.A., Royden, C.S., Banks, M.S., Swenson, K.H. and Sekuler, A.B. (1990) Optic flow and heading judgements. Annual Meeting Abstract Issue, Assoc. for Res. in Vision and Ophth. 31: 522.

Crowell, J.A., Banks, M.S. and Royden, C.S. (1989) A physiologically plausible model of optic flow perception. Annual Meeting Abstract Issue, Assoc. for Res. in Vision and Ophth. 30: 427.

Royden, C.S., Crowell, J.A. and Banks, M.S. (1989) A biologically plausible model of optic flow perception. AAAI Spring Symposium Series: Robot Navigation: 75 - 79.

Leila Schneps

Curriculum Vitae

[redacted]

PII Redacted

Education

1983 B.A. in Mathematics and German Language and Literature
Harvard/Radcliffe University, Cambridge, Massachusetts, USA

1985 Doctorat de Troisième Cycle in Mathematics
Université de Paris XI, Paris, France
Thesis Director: Professor John Coates
Title (in English): On the μ-invariant of p-adic L-functions attached to elliptic curves with complex multiplication.

1990 Doctorat de l'Université de Paris XI
Thesis Director: Professor Guy Henniart
Title (in English): p-Adic L-functions, and Galois groups.

Professional Experience

1979-83 Tufts University Physics Department, Boston, Mass. USA
Programmer

1980-83 Harvard University Math Department, Cambridge, Mass. USA
Course Assistant in Math 21a, Math 106, Math 251.

1981-82 M.I.T. Plasma Fusion Center, Cambridge, Mass. USA
Programmer

1984 University of Maryland, European Division, Kaiserslautern, Germany
Lecturer in Mathematics (First Semester)

1984-85 Université de Paris XI, Paris, France
Course Assistant

1985-86 Université Scientifique et Médicale de Grenoble, France
Maître de Conférences (Assistant Professor)

1986-87 Université de Paris XI, Paris, France
Maître de Conférences (Assistant Professor)

1988-89 Max-Planck Institut für Mathematik, Bonn, Germany
Researcher

1989-90 Université de Paris 7, Paris, France
Maître de Conférences (Assistant Professor)

1990-91 Eidgenossische Technische Hochschule, Zürich, Switzerland
Postdoctorate Assistant

1991 CNRS, Faculté des Sciences de Besançon, France
Chargé de Recherche (Researcher)

Publications

(1) On the μ-invariant of p-adic L-functions attached to Elliptic Curves with Complex Multiplication, *J. Numb. Th.* **25** No. 1 (1987), 20-33.

(2) p-Adic Interpolation of Special Values of Hecke L-functions, with P. Colmez, *Comp. Math.* **82** (1992), 143-187.

(3) Explicit realisations of subgroups of $GL_2(\mathbf{F}_3)$ as Galois groups, *J. Number Theory* **39** No. 1 (1991), 5-13.

(4) $\tilde{D}_4$ et $\hat{D}_4$ comme groupes de Galois, Note aux *C. R. Acad. Sci. Paris*, t. **308**, Série I (1989), 33-36.

(5) Explicit construction of extensions of $\mathbb{Q}(T)$ of Galois group $\tilde{A}_n$ for n odd, *J. Alg* **146**, No. 1 (1992), 117-123.

(6) Construction explicite de 2-groupes extra-spéciaux comme groupes de Galois sur $\mathbb{Q}(T)$, *Publ. Math. Fac. Sci. Besançon, Th. des Nombres, Années 1989-1991.*

(7) On cyclic field extensions of degree 8, to appear in *Mathematica Scandinavica.*

(8) On reduction of p-groups, to appear in *Communications in Algebra.*

(9) On Galois groups and their maximal 2-groups, to appear in *Israel J. Math.*

(10) Polynômes à groupe de Galois diédral, to appear in *Sém. Th. Nombr. Bordeaux*

(11) On cyclic field extensions of 2-power degree, to appear.

(12) Dessins d'enfant on the Riemann sphere, to appear.

Lectures

Since 1990: lectures at the Universität Heidelberg, Germany; at Cambridge University, England; at the Technion-Haifa, Israel; at the Université de Franche-Comté, the Ecole Normale Supérieure de Lyon, the Paris Number Theory Seminar, the Université de Rennes and the Université de Bordeaux, France and at the ETH-Zürich, Switzerland, on the subjects:

The inverse Galois problem for p-groups

The inverse Galois problem for the groups $\tilde{A}_n$

Introduction to the theory of dessins d'enfant

Dessins d'enfant in genus zero

Teichmüller spaces

Activities outside of research

Member of the societies European Women in Mathematics and Femmes et Mathématiques (organizing meeting, writing articles etc.)

Member of the French Federation of Go Players (international tournaments)

Militant anti-apartheid activist, member of the French Mouvement Anti-Apartheid

Foster parent to a Philippine child

Lisa Vawter

PII Redacted
[redacted]

Museum of Comparative Zoology Labs
Harvard University
Cambridge, MA 02138

Education

1983-1991	University of Michigan, Ph.D. Biology
1979-1982	Washington University in St. Louis, A.B. Biology

Professional Experience

1992-present	Harvard University Postdoctoral Fellow
1991-1992	University of East Anglia NSF-NATO Postdoctoral Fellow
1989-1991	University of Michigan Lab Manager
1982-1983	St. Louis University Medical School Technician

Professional Accomplishments

Vawter, L. and W.M. Brown 1986 Nuclear and mitochondrial DNA comparisons reveal extreme rate variation in the molecular clock. Science 234:194-196.

NSF-NATO Postdoctoral Fellowship

Invited Seminar: Rice University, University of Kansas, University of Michigan, Harvard University, Oxford University, Boston University, University of Paris.

Honors and Awards

NSF-NATO Postdoctoral Fellowship
Rackham Predoctoral Fellowship
Walker Scholarship
Edwin Edwards Fellowship
Hinsdale Scholarship
NSF Predoctoral Fellowship
Mellon Research Fellowship
Washington University Scholarships
Tietjens Fellowships
NASA Benjy F. Brooks Scholarship
Beta Sigma Phi International Scholarship

APPENDIX C.

COLLOQUIA AND TALKS DELIVERED BY 1994 SCIENCE SCHOLARS

Rama Bansil

"Why Doesn't the Stomach Digest Itself?" Colloquium at the Bunting Institute, Dec. 15, 1993 and at the Physics Department at Brandeis University in June, 1994; and brown bag lunch presentation at Bunting Institute Dec. 16, 1993;

Other: "The Aggregation and Gelation of Mucin," at the Gordon conference on Macromolecular and Polyelectrolyte Solutions, Oxnard California, Feb. 1994; "Mucin: Aggregation and Colloidal Interactions Relevant to Some Biological Problems" at the First International Conference on Scaling Concepts and Complex Fluids, Catanzaro, Italy, July 1994.

Susan Circone

"Compressibility of Titanium-Bearing Silicate Liquids," Colloquium, Bunting Institute, May 18, 1994; and brown bag lunch presentation at Bunting Institute the day following.*

Rosanne DiStefano

"White Dwarfs, Supersoft X-Ray Sources and Selected Other Astrophysical Delights," Colloquium, Bunting Institute, Oct. 6, 1993; and brown bag lunch presentation at Bunting Institute the day following.
Other: "The Role of Two-Body Tidal Capture in Global Clusters" and "On the Nature and Population of Luminous Supersoft X-Ray Sources," with Saul Rappaport at Aspen Workshop on Millisecond Pulsars, Jan. 1994; "A Search for Chaos in the Rapid Buster," with M. Bockrath and Saul Rappaport at the October Conference on X-Ray Binaries.

Florence Lin

"Geometric Mechanics and Molecular Control," Colloquium, Bunting Institute, Jan. 26, 1994; and brown bag presentation at Bunting Institute the day following.
Other: "Geometric Approach to Computational Molecular Control," Harvard-Radcliffe Science Poster Session, Sept. 30, 1993; "The Dynamics of a Molecular Oscillator in an Electric Field as a Reversible

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* Information on talks not available in report.

Hamiltonian Control System," Monday Dynamics Seminar, Department of Mathematics, Boston University, April 11, 1994; "A Geometric Integration Algorithm for Quantum Molecular Dynamics and Control," poster presented at Workshop on Integration Algorithms for Classical Mechanics, The Fields Institute for Research in Mathematical Sciences, Waterloo, Ontario, Oct 14-17, 1993; Reduction and Optimization of Hamiltonian Control Systems with Symmetry and Applications in Molecular Control," at SIAM Annual Meeting, San Diego July 25, 1994; "Sympletic Methods for Applications in Computational Quantum Molecular Control, poster CP-3.05, Cornelius Lanczos International Centenary Conference North Carolina State University, Raleigh, NC, Dec. 12-17, 1993.

Lauren Rose

Combinatorics, Geometry and Multivariate Splines, Colloquium, Bunting Institute, June 1, 1994; and brown bag presentation at Bunting Institute the day following.
Other: Modules of Piecewise Polynomials, Valley Geometry Society Seminar, U-Mass. Amherst, Oct. 1993; Piecewise Polynomials on Polyhedral Complexes, University of New Hampshire Math. Dept. Colloquium April 1994; Lexicographic Ideals and Simplicial Complexes, Combinatorics and Graph Theory Day at Smith College, April 1994 and at Combinatorics Seminar, MIT, April 199; Graphs and Syzygies of Polynomials, Fellowship of the Ring Seminar, Brandeis University, April 1994; Piecewise Polynomials on Polyhedral Complexes, Combinatorics Seminar at MIT, April 1994 and at SIAM Confrference on Discrete Math, Minisymposium in Albuquerque, June 1994.

Constance Royden

"Human Heading Perception in the Presence of Moving Objects," Colloquium, Bunting Institute, Nov. 17, 1994; and brown bag presentation at Bunting Institute the day following.
Other: "The effects of moving objects on heading perception." Association for Research in Vision and Opthamology Anual Meeting, Sarasota, FL, May 5, 1994; "Human Heading Perception: Computational Modeling and Pyschophysics," at Woods Hole, MA. August 25, 1994.

Leila Cynthia Schneps

"The Absolute Galois Group from a Geometric Viewpoint," Colloquium, Bunting Institute, May 25, 1994; and brown bag presentation at Bunting Institute the day following.

Other:
"Dessins d'enfants and geometry of modulie space, workshop, Berkeley, 22-25 April 1994; talks also at Harvard, Cincinnati, Yale, Berkeley, Los Angeles, and undergraduate "math table"at Harvard.

Lisa Vawter

"Evolutionary Genetics of Termites," Colloquium, Bunting Institute, April 13, 1994; brown bag presentation at Bunting Institute the day following.*

* Information on other presentations not available.

APPENDIX D.

SELECTION COMMITTEE MEMBERS

FOR

1993-4 SCHOLARS

COMMITTEE MEMBERS SECOND STAGE REVIEW

Howard Berg, Professor of Biology, Harvard University

Susan Carey, Professor of Experimental Psychology, MIT

Melissa Franklin, Professor of Physics, Harvard University

Irene Little-Marenin, Associate Professor of Astronomy, Wellesley College

Nanette Orme-Johnson, Professor of Biochemistry, Tufts Medical School

Allan Robinson, Gordon McKay Professor of Geophysical Fluid Dynamics, Harvard University

Yum-Tong Siu, William Elwood Byerly Professor of Mathematics, Harvard University

John Wood, Professor of the Practice of Geology, Harvard University

Final Report for Bunting Science Scholar Award

Rama Bansil

The year was devoted to work on two problems related to studies of mucin, the biopolymer which covers all epithelial surfaces. I co-authored four papers including a solicited review article on the biophysics of mucin and gave four talks on the subject. A brief description of the progress on the different problems is given below.

I. Biophysical studies of gastric mucin The first problem deals with the application of biophysical techniques of light scattering to investigate the gelation and aggregation properties of gastric mucin. which plays a key role in the ability of the stomach to not digest itself. In addition to continuing the work on static and dynamic light scattering which are sensitive to the macroscopic shape and size of mucin new work was begun on the application of spectroscopic techniques which give insight into the molecular structure and conformation of these macromoleculess.

We made the first measurements of the infrared and Raman spectra of mucin solutions as well as in the solid state. The data show that the structure of the water bound to mucin changes significantly as the pH is reduced from 7 to 2, suggesting that the interaction of mucin with water may be related to its physiological function. We also found that the infrared spectrum of gastric mucin was very similar to that of gallbladder mucin. implying that mucins from different organs have similar secondary structure. i.e., the conformation of the peptide backbone and the arrangement of the carbohydrate side chains.

We have set up a new apparatus to do depolarized dynamic light scattering. Normally dynamic light scattering is done with the polarization of the incident and scattered light parallel to each other. For anisotropic molecules, such as mucin. there may be a significant scattering where the polarization of the scattered beam is perpendicular to that of the incident beam. Preliminary measurements indicated that this depolarized scattering is very strong for the large aggregates that we observe in gastric mucin solutions at pH below 4. However, the quality of the polarizers used was not good enough to permit a quantitative analysis of the depolarized spectrum to obtain the rotational diffusion constant. This has now been remedied by changing to polarizers with very high extinction ratio and the new apparatus has been carefully aligned so that the two polarization components can be separated to one part in 10^6. Over the next year we hope to complete this quantitative study which will allow us to determine the size and shape of mucin molecules and aggregates as a function of pH and concentration.

In our previous work we had observed that aggregation of mucin occured at pH below

4. I have recently suggested a possible mechanism for this phenomenon. By examining the amino acid composition and sequence of mucins, I suggest that the aggreagation occurs below pH4 because that coincides with the pK of aspartic acid and glutamic acid residues present in the non-glycosylated regions of the mucin molecule. At pH less than the pK these groups are protonated which decreases the electrostaic repulsion between neighboring mucin molecules allowing them to get closer. This enhances the entanglement of mucin molecules or promotes the formation of secondary bonds between monomers leading to aggregation and eventually gelation. This hypothesis is described in a review article for the Annual Reviews of Physiology on Mucin Biophysics that I co-authored with Drs. LaMont and Stanley.

II. Interactions of gallbladder mucin with phosphlipid vesicles We are examining the hypothesis that mucin-lipid interactions are involved in the first step of the process that leads to cholesterol crystallization and the eventual formation of gallstones. We used dynamic light scattering to measure the size of pho spholipid cholesterol vesicles as a function of time after the addition of mucin. Our results show that the vesicles fused in leass than an hour after the addition of mucin. The fusion increases the cholesterol concentration which is a key requirement for crystal nucleation to occur. To determine whether this fusion involves specific lipid-mucin interactions or whether it would happen with any particle and any polymer we performed similar experiments with mucin added to synthetic latex particles and with polyacrylammide, a synthetic polyme, added to phospholipid vesicles. We found that mucin did not cause latex particles to aggregate. Secondly we found that at similar concentrations, polyacrylamide, a synthetic water soluble polymer did not cause vesicle fusion. These results suggest that there is a specific interaction between mucin and phospholipid - cholesterol vesicles which causes fusion to occur at very small concentrations of mucin. Further work is underway to investigate the phase behavior of mucin-phospholipid vesicle complexes over a wide range of concentrations of the two components. A paper describing some of these results has been submitted to J. Biol. Chem.

Impact of fellowship on my career This fellowship has allowed me to focus on a new research problem in the area of biophysics. I found the time to learn about mucin and to make valuable connections between the work that I have been doing with synthetic polymer gels with the more complex biological gels. The new apparatus that I set up

for depolarized light scattering will allow me to measure rotational diffusion constants, opening up possibilities for future experiments with rod-like polymers. Most of all I valued the time that I was able to devote to research, unfettered by the usual duties of a faculty member. The presentations that I made about mucin were well received and will lead to future collaborations with other scientists interested in applying physical eetchnique to study biological phenomena.

Talks

[1] COLLOQUIUM: Bunting Institute, Radcliffe College, Dec. 1993. "Why the Stomach Doesn't Digest Itself?"

[2] COLLOQUIUM: Physics Dept., Brandeis University, Jan. 1994. "Why the Stomach Doesn't Digest Itself and what Does This Have to do With Gels?"

[3] INVITED TALK: Gordon Conference on Macromolecular and Polyelectrolyte Solutions, Oxnard Calif., Feb. 1994 "The Aggregation and Gelation of Mucin"

[4] INVITED TALK: First International Conference on Scaling Concepts and Complex Fluids, Catanzaro, Italy July 1994 " Mucin: Aggregation and Colloidal Interactions Relevant to some Biological Problems"

Publications

[1] R. Bansil, H. E. Stanley and J. T. LaMont, " Mucin Biophysics" Annual Rev. of Physiology **57** (1995, in press).

[2] C. S. Kuo, R. Bansil and C. Konak, " Tracer Diffusion of Flexible Probes in Gels near the Sol-Gel transition" Macromolecules (submitted)

[3] R. Bansil "Mucin: Aggregation and Collidal interactions relevant to some biomedical problems" Proceedings of the First Interantional Conference on Scaling Concepts in Complex Fluids, to appear in Nuovo Cimento (1995)).

[4] N. H. Afdhal, N. Niu, D. N. Nunes, R. Bansil, X. Cao, D. Gantz, D. Small and G. D. Offner, "Validation of a Resonance Energy Transfer Assay to examine Vesicle Fusion and Cholesterol Crystal Nucleation from Model Bile: Effect of Gallbladder Mucin." J. Biol. Chem. (submitted).

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

SUSAN CIRCONE

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

Year-End Report of Susan Circone (Geologist)
1993-1994 Science Scholars Fellowship / Office of Naval Research
August 4, 1994

The year at the Bunting Institute truly has been wonderful, and it saddens me that the end has finally arrived. The year has been quite productive scientifically. My research accomplishments fall along two lines: commencing the study outlined in my proposal of determining the compressibility of titanium-bearing silicate liquids and finishing research previously started during my position as a postdoctoral research fellow at Harvard University. The details are summarized below. In addition to the important progress that I have made in my research, the funding provided through ONR has given me the unique opportunity to interact with a group of remarkable women. They represent a diversity in interests, age, and backgrounds that I have not encountered amongst my peers in science. What I have gained in knowing them is at least as important and significant as the research that I have accomplished. It is an opportunity unique to the Bunting Institute and one not afforded by other fellowship programs. It has been a privilege to be here this past year.

The primary purpose of the research project "Compressibility of titanium-bearing silicate melts" is to determine the change in volume or density with pressure of these liquids and to investigate the effect of cation coordination state (the number of oxygens bonded to each cation) on liquid compressibility. Measurements of compressibility are crucial for understanding the behavior of silicate liquids in geologic settings and are applicable to magmatic processes such as volcanism and to the early history of terrestrial bodies. The effect of pressure on silicate liquid structure and compressibility currently is not well-known. Titanium-bearing silicate liquids were chosen because 1 atm density measurements indicate that liquid composition significantly affects the coordination state of titanium.

At high pressure, silicate liquid density is measured by determining the buoyancy of crystalline spheres in the liquid. Since the sphere densities at experimental conditions are known, the sinking (more dense than the liquid) or floating (less dense) of the spheres constrains the density of the liquid. Spheres with slightly higher zero pressure densities are selected. With increasing pressure, the density of a silicate liquid increases more rapidly than that of the crystalline spheres (due to a higher compressibility). Therefore, at some pressure their densities will become equal. By determining the location of these equivalent density points for various spheres in pressure space, the density of the liquid can be bracketed at several pressures.

Initial experiments performed last fall on $CaTiSiO_5$ (CTS) liquid have been encouraging, although some technical problems were encountered. Experiments were performed at 0.8 - 2.0 GPa (1485 - 1560 °C) to bracket the density crossover of CTS liquid with pure Mg_2SiO_4 olivine (Fo100) spheres. The Fo100 spheres should become less dense than the CTS liquid (i.e. float) above ~1.8 GPa (based on 1 atm ultrasonic data). However, the Fo100 spheres floated in *all* of the experiments. Since the spheres dissolved somewhat during the experiment and altered the liquid composition, I initially concluded that the contaminated liquid surrounding the spheres

affected the apparent sphere density and contributed to their buoyancy, thus yielding an inaccurate measurement. However, subsequent high-pressure density measurements on a natural, titanium-bearing liquid (see below) indicate that the presence of titanium increases the compressibility relative to titanium-free liquids of similar composition. Further experiments on the simple liquids are warranted.

My most significant research progress has been made this spring and summer, during which I have been determining the compressibility of a pristine lunar basalt liquid. Lunar basalts are an important feature of the lunar surface, forming the lunar maria. The results of this study have implications for the evolution of the moon. Radically different depths of origin (~150 vs. 400 km depth) have been proposed for the suite of pristine lunar basalt glasses, which were emplaced during the late stages of lunar volcanism 3.1 - 3.8 billion years ago. Experimental determination of lunar basalt liquid compressibility will provide important constraints on their formation and depth of origin. I have completed most of the density measurements on a lunar basalt liquid that contains 16.4 wt % TiO_2 (Fig. 1). Two more brackets at higher pressure are needed to complete the project. Sink/float experiments in the 7.0-8.0 GPa pressure range are currently underway.

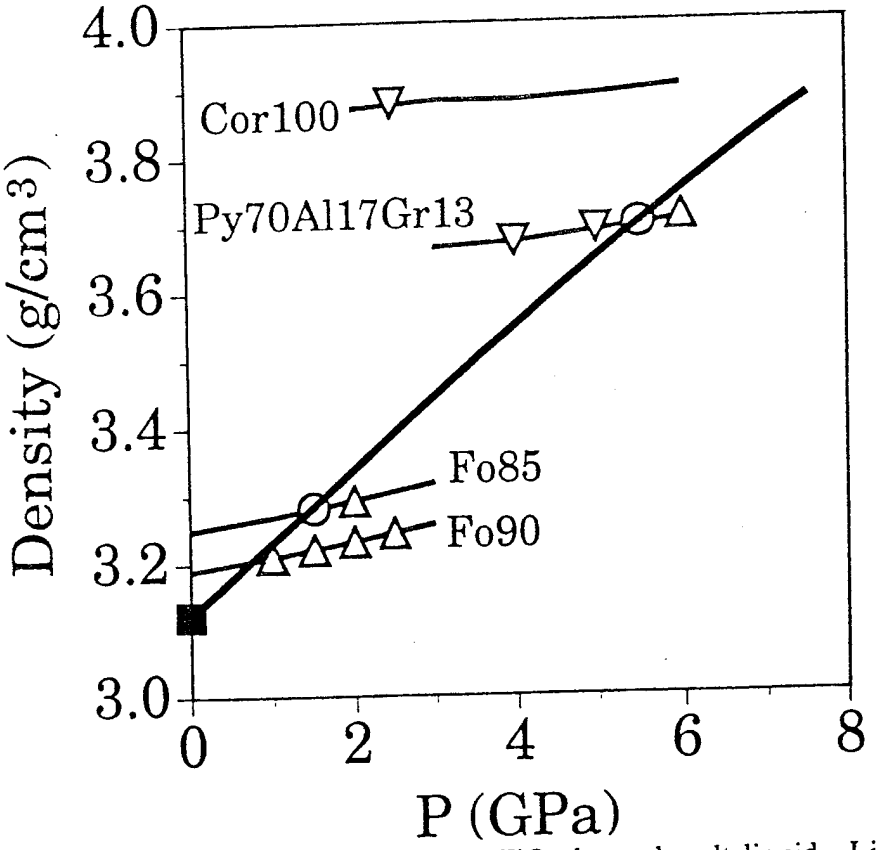

Fig. 1. Sink/float experiments on high-TiO_2 lunar basalt liquid. Lines show known densities of spheres at P, T: Fo90 and Fo85 are Mg-rich olivines, Py70Al17Gr13 is a Mg-rich garnet, and Cor 100 is corundum. Upward pointing triangles indicate that spheres floated, downward pointing triangles indicate that spheres sank, and circles indicate spheres neutrally buoyant.

These experiments have provided two important results. First, the observed slope of the liquid density vs. pressure (0.10 g cm^{-3}/GPa) is a factor of ~1.5 steeper than the slope observed for TiO_2-free ultrabasic liquids of similar composition (0.07 g cm^{-3}/GPa; Agee and Walker 1988, Journal of Geophysical Research 93, 3437-3449). The enhanced compressibility of the lunar basalt liquid must be related to its high TiO_2 content. This important result emphasizes the need for determining compressibility on a range of liquid compositions, especially those containing titanium, to elucidate the factors that control silicate liquid densities at high pressure. Second, the observed density - pressure relationships for the TiO_2-rich lunar basalt liquid indicate that the magma would have been neutrally buoyant at a depth of ~400 km (2.0 GPa) in a lunar mantle comprised of relatively Fe-rich olivine and orthopyroxene. However, a lunar mantle derived from cumulates sinking in a magma ocean would be composed of more magnesium-rich minerals with lower bulk density at depths of 400 km. This scenario favors a shallower source region for the most Fe, Ti-rich magmas, since the magma would have been too dense to have been emplaced at the lunar surface. These results were presented in my colloquium given at the Bunting Institute on 18 May, 1994. This September I will also submit an abstract to give a paper at the 1994 Fall American Geophysical Union Meeting in San Francisco, and this fall I will prepare the manuscript for publication.

In addition to the work on titanium-bearing silicate liquids, I have worked on a few other projects. This summer, I performed experiments to establish the temperature gradient relationships in the multi-anvil apparatus. These results will be summarized in a technical paper this fall. During the fall and winter, I finished work on a high-pressure phase equilibrium study of "Liquid immiscibility in the system TiO_2 - SiO_2 at 3.0 GPa" by S. Circone and C.B. Agee, which was submitted for review and publication in Geochimica et Cosmochimica Acta in February (copy attached). It is currently undergoing minor revisions for publication. Last fall I also performed some preliminary high-pressure density measurements to determine the compressibility of Allende meteorite liquid. These experiments will be continued by a graduate student working in Prof. Agee's laboratory. Finally, during the winter I performed some thermodynamic calculations on the phase diagram of SiO_2 at high pressure and temperature. These calculations are part of a high-pressure experimental study of the kinetics of quartz growth at high-pressure that I have been working on. Further experimental work is required on this project before submitting the results for publication.

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

ROSEANNE DISTEFANO

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

Rosanne Di Stefano

Year-End Report (1993-94)

When I started the first of my two Science Scholarships at the Bunting Institute, I was in the middle of making a major research career change from field theory to astrophysics. I had one published paper in astrophysics. During my first Bunting year, 1992-93, I started and completed work on a major project to predict the number of CVs that might be present in globular clusters due to two-body tidal capture. That project was important in helping me to gain some recognition in the community of astrophysicists.

In some sense, my second year as a Bunting Science Scholar was even more important than the first. In that year, I moved from MIT, which was the only institution I had been associated with while making the change to astrophysics, to Harvard. This move brought me into contact with a larger number of people in this field than I had known before, and allowed me to develop a broader perspective on research in astrophysics. More importantly, I was able to complete several pieces of work started during the first year and to start and complete several others, so that at this point, my research portfolio in astrophysics has three clear areas of strength, with multiple publications in each area. A list of my published work in astrophysics accompanies this report. Two papers for which the research was done during the Bunting year do not appear on this list, because they have not yet been published.

Also during the 1993-94 Bunting year, I applied for two major grants, which were funded. One is from the NASA theory program (this was written with Saul Rappaport of MIT); the second, a VPW visiting professorship, gives me the opportunity to spend two additional years at Harvard as a faculty member.

Selected astrophysics papers:

Close Binarues in Globular Clusters :

- *Production of Recycled Pulsars in Globular Clusters Via Two-Body Tidal Capture,* R. Di Stefano and S. Rappaport; *Ap.J.*, 396, 587 (1992).
- *Predictions of a Population of CVs in Globular Clusters,* R. Di Stefano and S. Rappaport; *Ap.J.*, 423, 274 (1994).
- *The Role of Two-Body Tidal Capture in Globular Clusters,* R. Di Stefano; to appear in the proceedings of the January 1994 *Aspen Workshop on Millisecond Pulsars.*
- *Formation and Evolution of Cataclysmic Variables in Globular Clusters,* S. Rappaport and R. Di Stefano; in *Proceedings of the 2nd Technion Haifa Conference on Cataclysmic Variables and Related Objects,* Eilat, Israel, January 1993, edited by O. Regev and G. Shaviv.
- *The Relation Between White-Dwarf Mass and Orbital Period in Wide Binary Radio Pulsars,* S. Rappaport, Ph. Podsiadlowski, P.C. Joss, R. Di Stefano, and Z. Han, submitted to *MNRS.*

Luminous Supersoft X-Ray Sources :

- *The Derived Population of Luminous Supersoft X-Ray Sources,* R. Di Stefano and S. Rappaport; to be published in the *Astrophysical Journal,* 20 December (1994).
- *Formation and Evolution of Luminous Supersoft X-Ray Sources,* S. Rappaport, R. Di Stefano and J.D.Smith; *Ap.J.*, 10 May 1994.
- *On the Nature and Population of Luminous Supersoft X-Ray Sources,* R. Di Stefano and S. Rappaport; to appear in the proceedings of the January 1994 *Aspen Workshop on Millisecond Pulsars.*

Gravitational Microlensing by Binary Systems :

- *Interpretation of Gravitational Microlensing by Binary Systems,* S. Mao and R. Di Stefano; to appear in *The Astrophysical Journal,* February 10 (1995).
- *The Optical Gravitational Lensing Experiment. OGLE #7: Binary Microlens or a New Unusual Variable?,* to appear in *The Astrophysical Journal Letters,* December 1 (1994).

Other :

- *A Search for Chaos in the Rapid Burster,* M. Bockrath, R. Di Stefano and S. Rappaport; to appear in the proceedings of the 'October Conference on X-Ray Binaries'.

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

FLORENCE LIN

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

7/94

Report for 1993-94: Geometric, numerical, and nonlinear dynamical systems studies in molecular dynamics

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This report summarizes research projects developed and presentations made by the author as a Science Scholar at the Bunting Institute during the 1993-94 year.

1. Introduction

This report describes accomplishments for 1993-94. This includes projects on control in the Poisson context (sections 2 and 3), projects on symplectic integration algorithms (sections 4, 5, and 7), and projects on Hamiltonian vector fields and symplectic forms relevant to the control of molecular dynamics (sections 6 and 8). Several scientific presentations were made (section 9).

2. Poisson reduction and optimization of Hamiltonian control systems with symmetry

This paper uses the techniques of geometric mechanics to discuss the commutativity of the operations (i) reduction of Hamiltonian dynamical systems with symmetry and (ii) optimization of control systems when applied to Hamiltonian control systems with symmetry. The dynamics of the reduced control system drops to a Hamiltonian dynamical system on a reduced phase space. The symplectic structure of the reduced control system is, in general, not necessarily canonical. This is discussed in terms of the Lie group describing the symmetry and the related physical manifestations in classical mechanics and classical electrodynamics. These results are discussed in the context of Poisson manifolds and then applied to an example relevant to optimal molecular control.

This builds on the techniques described in "Symplectic reduction and topology for applications in classical molecular dynamics" (Lin and Marsden, 1992). The results developed here (Lin, 1993c) are not restricted to the control of molecular dynamical systems but are relevant to the control of mechanical systems in general. The current paper extends the previous reduction results as follows: it puts the previous results for systems in $\mathbf{R}^2$ in the more general setting of results for systems in $\mathbf{R}^3$, and extends the previous results for systems with symmetry described by an abelian Lie group to include systems with symmetry described by a nonabelian Lie group.

3. Controllability and optimal Poisson control systems for applications in molecular control

The relevance of geometric mechanics to the description of classical molecular dy-

namics has recently been discussed. The formalism of Hamiltonian dynamical systems with symmetry is applicable to both the bound and unbound trajectories of molecular systems. This includes rotating, vibrating molecules; elastic, inelastic, and reactive scattering; molecular orientation and alignment; and molecular dissociation. The geometric technique of Poisson reduction is useful in discussing (i) the controllability of dynamical systems and (ii) a necessary condition for optimal control. Techniques based on the stability of differential equations or based on nonlinear dynamical systems are also relevant to the determination of controllability. This paper examines the applicability of these techniques to the determination of (i) the attainability of a reactive molecular collision and (ii) a necessary condition for the optimal control of molecular reaction dynamics. The results for autonomous dynamical systems are directly applicable to the autonomous molecular control problem of the attainability of electric field-induced orientation or alignment of reactant molecules for stereospecific chemical reactions. These results are a mathematical step toward the geometric solution of the nonautonomous problem of laser-induced molecular dissociation.

This paper (Lin, 1993e) extends the previous description (Lin, 1993c) of optimality of control systems in the Poisson context to the description of attainability, accessibility, and controllability. It then applies these results to the control of the orientation or alignment of reagent molecules for a chemical reaction. This paper also uses techniques not used in the previous studies (Lin and Marsden, 1992; Lin, 1993c), e.g., those based on the stability of differential equations and based on nonlinear dynamical systems theory.

4. Symplectic reduction and numerical integration of Hamiltonian dynamical systems with symmetry and applications in molecular dynamics and control

The aim of this paper (Lin, 1993b,d, 1994c) is to introduce mathematical scientists with interests in Hamiltonian dynamical systems and numerical analysis and scientific computing to some symplectic and numerical techniques that may be useful. The technique of reduction for symplectic manifolds with symmetry will be described for both finite- and infinite-dimensional manifolds, so it will be applicable to both ordinary and partial differential equations. The commutativity of reduction and quantization will be described for the special case of the symplectic manifold being a cotangent bundle. Then some numerical techniques for integrating ordinary differential equations will be described followed by the description of an extension for integrating partial differential equations. Specific numerical integration techniques preserving the symplectic structure (the form of Hamilton's equations) at each time step will be discussed. These results are generally relevant to the Hamiltonian dynamics described by systems of ordinary or partial differential equations and show the utility of reduction in decreasing the number of differential equations or in decreasing the dimension of the configuration space in the original system of equations in order to decrease the computation time required to numerically integrate an initial value problem. In particular, the results are relevant to classical systems described by Hamilton's equations and quantum systems described by the time-dependent Schrödinger equation. Specific applications in classical and quantum molecular dynamics and control are mentioned. This is a rationale for the development of a symplectic integration algorithm described here. This algorithm is useful for problems in quantum molecular

dynamics and control.

5. Runge-Kutta methods for integrating Hamiltonian vector fields corresponding to noncanonical symplectic forms

The motion of a particle in a magnetic field is described by the Lorentz force law and by a noncanonical symplectic form comprised of the sum of the canonical symplectic form plus a magnetic term. This paper shows that when ρ-th order, s-stage Runge-Kutta methods with Butcher tableaux satisfying the condition $\mathbf{m} = 0$ are used to integrate the Hamiltonian vector field, they preserve this noncanonical symplectic form exactly. The motion of a rigid body is described by Euler's equations and by another noncanonical symplectic form, the Kirillov-Kostant-Souriau symplectic form. When ρ-th order Runge-Kutta methods are used to integrate the Hamiltonian vector field, the local error in the Kirillov-Kostant-Souriau symplectic form after one time step h is $\mathcal{O}(h^{\rho+1})$. This work (Lin, 1994e) extends previous studies of Runge-Kutta methods for integrating Hamiltonian vector fields corresponding to the canonical symplectic form.

6. The Hamiltonian vector field for Euler's equations in terms of the Kirillov-Kostant-Souriau symplectic form

The (reduced) Hamiltonian vector field and (reduced) symplectic form for rigid body motion described by Euler's equations can be derived from the cotangent bundle reduction theorem corresponding to the conservation of the magnitude L of the angular momentum. For Euler's equations, the dimension of the Hamiltonian vector field is apparently *odd*; specifically, it appears to be 3. (However, the dimension of the reduced phase space is even, i.e., the dimension of the 2-sphere S_L^2 is 2.) Further, the Hamiltonian vector field $\mathbf{X}_{\mathbf{H}_L}$ on the reduced phase space is given by the Kirillov-Kostant-Souriau symplectic form $\omega_{KKS,L}$ parameterized by the value of L with the usual roles of the Hamiltonian vector field $\mathbf{X}_{\mathbf{H}_L}$ and the exterior derivative $\mathbf{d}H_L$ of the Hamiltonian *reversed*, i.e., $\mathbf{X}_{\mathbf{H}_L}$ satisfies

$$-\omega_{KKS,L}(\Pi)(\mathbf{d}H_L, \mathbf{v}_L) \;=\; \mathbf{X}_{\mathbf{H}_L} \cdot \mathbf{v}_L \quad \text{for all } \mathbf{v}_L \in TP_L \quad ,$$

where the reduced symplectic form ω_L is given by $-\omega_{KKS,L}$, Π is a point in the reduced phase space P_L, and H_L is the reduced Hamiltonian defined on the reduced phase space (Lin, 1994g).

7. Partitioned Runge-Kutta methods for integrating Hamiltonian vector fields corresponding to the canonical symplectic form

This paper (Lin, 1994f) uses partitioned Runge-Kutta methods to numerically integrate Hamilton's equations with initial conditions. Such methods have been derived previously by requiring the preservation of the canonical symplectic form at each time step and have led to a sufficient condition that the matrix $\mathbf{M}$ (whose elements are a function of the elements of the Butcher tableaux for the method) vanishes. Alternatively this paper shows that such methods can also be derived by using the Baker-Campbell-Hausdorff formula for evaluating the flow of a Hamiltonian vector field. While discussed previously only for the case of autonomous Hamiltonian dynamical systems, this paper now uses these methods to explicitly treat nonautonomous Hamiltonian dynamical systems, e.g., Hamiltonian control

systems. Examples are chosen from potentially chaotic Hamiltonian dynamical systems and from Hamiltonian control systems relevant to the dynamics and control of molecular dynamical systems.

8. An application of reduction and optimization of Hamiltonian control systems with symmetry

This paper (Lin, 1994h) uses the techniques of geometric mechanics to discuss the commutativity of the operations (i) reduction of Hamiltonian dynamical systems with symmetry and (ii) optimization of control systems when applied to Hamiltonian control systems with symmetry. The dynamics of the reduced optimal control system drops to a Hamiltonian dynamical system on a reduced phase space. These results are applied to an example relevant to optimal molecular control. The results are discussed in the context of symplectic forms and Hamiltonian vector fields.

9. Presentations

Presentations of this work have been made in the Boston area for students (Lin, 1993a, 1993-94), nonspecialists (Lin, 1994a), and researchers (Lin, 1994b,d) and at various international mathematical meetings for specialists (Lin, 1993b,d, 1994i).

Acknowledgements

The author wishes to thank D. G. M. Anderson of the Aiken Computation Laboratory at Harvard University for helpful discussions. This work has been supported in part by a grant from the Office of Naval Research at the Bunting Institute and Harvard University. This work has been and continues to be supported in part by a grant (DMS-9308342) from the National Science Foundation at the University of California, Berkeley. The author has received partial support from the (respective) conference organizers for travel expenses to present research results (i) at the Workshop on Integration Algorithms for Classical Mechanics at the Fields Institute, Waterloo, Ontario, Canada, and (ii) at the Cornelius Lanczos International Centenary Conference at North Carolina State University, Raleigh. A related project was carried out with A. Staudt with partial support from the Radcliffe Dean's Office under the Radcliffe Research Partnerships Program. The author is grateful for the opportunity of being a member of the Mathematical Sciences Research Institute at Berkeley, CA, during the program on dynamical systems methods for partial differential equations.

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Lin, F. J., Controllability and optimal Poisson control systems for applications in molecular control, 1993e (in revision).

Lin, F. J., The dynamics of a molecular oscillator in an electric field as a reversible Hamiltonian control system, Monday Dynamics Seminar, Department of Mathematics, Boston University, April 11, 1994d.

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Lin, F. J., Geometric mechanics and molecular control, Bunting Institute Colloquium Series, January 26, 1994a.

Lin, F. J., The Hamiltonian vector field for Euler's equations in terms of the Kirillov-Kostant-Souriau symplectic form, 1994g (to be submitted).

Lin, F. J., Partitioned Runge-Kutta methods for integrating Hamiltonian vector fields corresponding to the canonical symplectic form, 1994f (in preparation).

Lin, F. J., Poisson reduction and optimization of Hamiltonian control systems with symmetry, 1993c (in revision).

Lin, F. J., Reduction and optimization of Hamiltonian control systems with symmetry and applications in molecular control, Session CP12, SIAM Annual Meeting, San Diego, CA, July 26, 1994i.

Lin, F. J., Runge-Kutta methods for integrating Hamiltonian vector fields corresponding to noncanonical symplectic forms, 1994e (submitted).

Lin, F. J., Symplectic methods for applications in computational quantum molecular control, poster CP-3.05, Cornelius Lanczos International Centenary Conference, North Carolina State University, Raleigh, NC, December 12-17, 1993d.

Lin, F. J., Symplectic reduction and numerical integration of Hamiltonian dynamical systems with symmetry and applications in molecular dynamics and control, 1994c (submitted).

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FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

LAUREN ROSE

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

ONR Year End Report: Algebraic Combinatorics and Multivariate Splines

Lauren L. Rose
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August 5, 1994

1 Summary

During the year I made substantial progress on the problem of characterizing spline modules in terms of the combinatorics, geometry and topology of the defining region. Spline modules are sets of piecewise polynomial functions defined on a subdivided region of Euclidean space. These sets have a module structure over a polynomial ring, via pointwise multiplication. Splines are of particular interest outside of mathematics because of their many applications, including computer graphics and surface modeling.

2 Articles/Work in Progress

1. *Combinatorics and Topological Invariants of Modules of Piecewise Polynomials*, accepted for publication in *Advances in Mathematics.*

In this paper we describe to what extent the freeness and homological dimension of spline modules is a combinatorial or topological condition. We show that in the case of continuous splines, the algebraic properties are combinatorially determined in most cases. We also introduce an alternative description

of spline modules as the syzygy module of a graph with a linear form assigned to each edge. Using the syzygy module we can better understand the role of geometry in determining the algebraic structure of spline modules.

2. *Graphs and Syzygies of Polynomials*, in preparation.

This paper is a continuation of the one above. We explore the syzygy module for arbitrary graphs G together with a set of linear forms L. We define the notion of a decomposition of (G, L) and show that if $(G, L) = (G_1, L_1) \oplus (G_2, L_2)$, then $syz(G, L) \cong syz(G_1, L_1) \oplus syz(G_2, L_2)$. We describe classes of complexes which decompose into cycles, and compute the Hilbert series of the $syz(G, L)$ in terms of the Hilbert series of the decomposition.

3. *Computing Bases of Spline Modules*, in preparation.

In this work we describe several methods for testing whether a given set of spline functions form a basis for the module they generate. In the case that they do form a basis, they also describe vector space bases for spline spaces consisting of piecewise polynomials of degree at most k, for each k. The latter is a problem from approximation theory.

4. *Iterated Homology and Nonpure Shelling*, with Art Duval, draft.

We develop an iterated homology theory for simplicial complexes and show that the Betti numbers are related to the shelling numbers of the shifted complex.

5. *Lexicographic Ideals and Simplicial Complexes*, work in progress.

We explore the structure of the simplicial complex associated to an ideal generated by monomials. When the monomials form a lexicographic initial segment the 1-skeleton of the complex is a chordal graph and the k-skeleton satisfies a higher dimensional analogue of this property.

3 Invited Talks and Presentations

1. Modules of Piecewise Polynomials, Valley Geometry Seminar, U-Mass Amherst, October 1993.

2. Piecewise Polynomials on Polyhedral Complexes, University of New Hampshire Math Dept Colloquium, April 1994.

3. Lexicographic Ideals and Simplicial Complexes, Combinatorics and Graph Theory Day, Smith College, April 1994.

4. Graphs and Syzygies of Polynomials, Fellowship of the Ring Seminar, Brandeis University, April 1994.

5. Piecewise Polynomials on Polyhedral Complexes, Combinatorics Seminar, MIT, April 1994.

6. Lexicographic Ideals and Simplicial Complexes, Combinatorics Seminar, Northeastern University, May 1994.

7. Combinatorics, Geometry and Multivariate Splines, Bunting Institute Colloquium, June 1994.

8. Piecewise Polynomials on Polyhedral Complexes, SIAM Conference on Discrete Math. Minisymposium, Albuquerque, June 1994.

4 Observations

My year at Bunting was an extremely fruitful one. Having a year free from the demands of teaching, advising and administrative duties was essential to my growth as a research mathematician. During the course of the year I developed a stronger sense of myself as a mathematician than I had before. I had always seen myself as a teacher of mathematics, but only a visitor in the realm of research. This was due in part to being a woman in a predominantly male field. In addition, as a faculty member at a small college I have less time to pursue my research than my university counterparts.

This year, I had the time and the resources to be a full participant in the realm of mathematical research. As a visiting scholar at MIT, I had access

to libraries, computers and the lively group of algebraic combinatorics researchers in the mathematics department. Many eminent mathematicians visit MIT each year, and this contributed greatly to the stimulating environment. At the Bunting Institute, the other fellows provided a great source of personal and intellectual support for my work. I spent most of my time with the other Science Scholars, three of whom were also mathematicians. I also had the unique opportunity, in my colloquium talk, to introduce a group of women scholars in all fields to the fascinating world of pure mathematics. My life and my work have been truly enriched by this past year at Bunting and MIT.

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

CONSTANCE ROYDEN

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

Year-end Report

Constance S. Royden

Bunting Institute Science Scholars Program

This is my second year of funding from the Bunting Institute Science Scholars Program. During my first year as a Bunting Fellow I finished some work that I began while in the lab of Dr. Martin Banks at UC Berkeley. In that lab I had done some psychophysical experiments testing models of how people judge their heading in the presence of eye rotations. While a Bunting Fellow, I did some computational modeling that explained the data we obtained in those experiments. I have presented the results of this work in several invited talks and have written two papers that will appear this year in the journal, *Vision Research.* That year I also designed and programmed an experimental system to run psychophysical experiments to test how people judge their heading in the presence of moving objects. This year, I have continued working on that project and I have been able to run a series of experiments examining this topic, with some unexpected results.

Computational Modeling:

During my work with Dr. Martin Banks at UC Berkeley, I conducted a set of experiments to determine how well humans judge their direction of motion when they are both translating and rotating. This type of motion occurs for a person moving along a straight line while making eye or head movements. We discovered that for moderate speeds of rotation, 2.5 and 5.0 degrees per second, people rely on information about eye movements to judge heading. When viewing a simulated translation over a textured ground plane while tracking a moving target on the screen, people can judge their heading quite accurately at tracking speeds up to 5 degrees per second. However, when people fixate a stationary target while the translation and rotation is simulated in the moving display, they no longer accurately report their heading even though the retinal image is identical to that of the previous condition (Royden et. al., 1992). In fact, the perception of the movement differs between the condition when observers move their eyes and the condition in which the eyes remain stationary. In the first case, observers report that they appear to be moving in a straight line while making an eye movement. In the second case, observers report that they are moving on a curved path. These results raise two questions that potential models of heading perception must address. First, how do observers incorporate the eye movement information into their heading calculation in the condition where observers move their eyes? Second, how does the brain calculate the curved path in the case where observers eyes are fixed, and what position on this path corresponds to their reported heading?

I examined the second of these two questions. I showed that the motion of points on the viewing screen in the case of simulated rotation is very similar to the motion that would occur if the observer were actually moving on a curved path, rather than moving in a straight path while rotating the eyes. I hypothesized that when the eyes are not moving, the visual system automatically chooses the curved path motion. It can rule out motion on a straight line while moving the eyes, because the oculomotor system provides the information that the eyes are not moving. I showed that if one finds the direction of a line from the observer's eye position through the closest visible point on the circular path, one can fit the experimental data well for all three surfaces we analyzed.

Many questions remain to be addressed with computational modeling. First, how does the visual system incorporate information about eye movements into the computation of heading? It must somehow convert information about the speed and direction of an eye movement into information about the resulting motion of the visual image. It must then take this information into account when calculating heading.

Second, how does the visual system deal with objects that are moving relative to the rest of the scene? The presence of these moving objects complicates the problem of judging heading even in the case of pure translation. Hildreth (1992) has proposed one possible model that can accurately calculate heading in the presence of moving objects. I hope to modify this model to fit our current psychophysical data and to extend it to incorporate ideas generated from our ongoing experiments.

Psychophysical Experiments:

In my first year as a Bunting Science Scholar, I programmed an experimental paradigm to present sequences of images that simulated an observer's approach to a scene that combined a stationary surface and a moving object. The program was flexible so that I could vary numerous parameters, including surface structure, object size, speed, direction and position, as well as the simulated direction of motion of the observer.

This year, I have been using this experimental set-up to examine human heading perception in the presence of moving objects. In my initial experiments, I used the computer-controlled display to simulate observer motion toward two transparent frontoparallel planes. During this observer motion, a square object moved in front of the planes, moving either left, right, up or down with respect to the stationary scene. The displays lasted 0.8 seconds, at the end of which observers were asked to place a cursor on the position they perceived to be their heading. Most current computational models predict that heading accuracy will decrease as the size of a moving object increases. The speed and direction of the moving object should also have an effect, causing larger errors in heading judgments as the directions of the image velocities generated from the moving object deviate from those generated by the observer motion toward the rest of the scene. However, I found that the presence of a moving object has little effect on how well people judge their heading under most conditions. When the object did not cross the observer's path, it had no effect on the accuracy of heading judgements. When the object did cross the observer's path, I found that it caused a small bias in the heading judgements in the direction of object motion. This bias was dependent on object size, requiring a fairly large object (10 x 10 deg) to produce an effect. It also depended critically on the starting position of the object, occuring only when the object moved across the observer's heading during the trial. The bias generated was small (only about 2 deg of visual arc), but consistent. The direction of bias was in the opposite direction than that predicted by simple models of heading detection. Thus, the presence of a moving object in the scene generally has less effect on heading judgments than would be predicted by existing computational models. Furthermore, in conditions where the presence of a moving object does cause some effects on heading judgement, the direction of bias generated is inconsistent with the predictions of current computational models. I am currently conducting more experiments to try to elucidate the cause of the biases in heading estimation seen in these experiments.

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Hildreth, E. C. (1992) Recovering heading for visually-guided navigation. Vision Res. 32: 1177 - 1192.

Royden, C. S., Banks, M. S., and Crowell, J. A. (1992) The perception of heading during eye movements. Nature 360: 583 - 585.

Year-end Report **Constance S. Royden**

Presentations Given During Bunting Fellowship, 1993-94:

1. Human heading perception in the presence of moving objects. Bunting Institute Colloquium, Cambridge, MA. November 17, 1993.

2. The effects of moving objects on heading perception. Association for Research in Vision and Ophthalmology Annal Meeting, Sarasota, FL. May 5, 1994.

3. Human heading perception: Computational modeling and psychophysics. Woods Hole Workshop in Computational Neuroscience, Woods Hole, MA. Invited talk. August 25, 1994.

Publications:

Royden, C. S., Crowell, J. A., and Banks, M. S. (1994) Estimating heading during eye movements. Vision Research: In Press.

Royden, C. S. (1994) Analysis of misperceived observer motion during simulated eye rotations. Vision Research: In Press.

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Influence of the Bunting Fellowship:

The Bunting Science Scholars Fellowship has been a tremendous benefit for my career as a scientist. The two years of funding I have received have allowed me to continue my research at a critical time in my career. Because I made a major change in fields between my graduate work and my postdoctoral work, I have needed to spend extra time as a postdoctoral fellow to establish myself in my new field of computational neuroscience. The time I spent as a Bunting Fellow has been extremely important, and during the last two years I have become quite well known for the work I am doing. Because of the papers I have published this year and the invited talks I have given over the last two years I now feel that I am in an excellent position to find a good faculty position in my area of research. Furthermore, my tenure at the Bunting institute has increased my self confidence and inspired me because of the interactions with other women scholars, particularly the Science Scholars. The blend of funding needed at an important time in my career, and the support given by the Bunting community has made this fellowship invaluable.

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

LEILA SCHNEPS

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

Leila Schneps, Bunting Institute Science Scholar, 1993-94

Activity report for the ONR

Activities outside of research. Over the winter, I spent several months editing a book of conference proceedings for a conference which I organized in France in April 1993, and which was the first conference ever organized on my research subject, commonly known as the theory of "dessins d'enfants", children's drawings, after Alexander Grothendieck (see below for details). The title of the book is "The Grothendieck Theory of Dessins d'Enfants", and it will appear shortly, published by Cambridge University Press. Unlike most conference proceedings, this one consists of many closely related articles, several of them introductory, which together form the essential basic text on the subject. I edited all the contributions myself, as well as writing the introduction, contributing one article written alone and one joint article with someone else. The fellowship at the Bunting Institute allowed me to spend a lot of time working on the editing, and the book was ready less than year after the conference, which is very rare in mathematics.

I also organized a workshop, on a different aspect of the same subject, namely "Dessins d'enfants and geometry of moduli spaces", in Berkeley. 22-25 April 1994. I organized the workshop in Berkeley because I was offered support and help from the MSRI, the Math Department and the Noetherian Ring (the local group of women mathematicians). I was invited to end the workshop by giving the MSRI-Evans lecture to a general audience of Berkeley mathematicians.

During the year, I was invited to give talks and colloquia at Harvard, Cincinnati, Yale, Berkeley, Los Angeles, (and the undergraduate "math table" at Harvard).

Research Activity. Besides completing final versions of the articles contributed to the book on Dessins d'Enfants, I wrote a new joint article together with P. Lochak, in which we investigate deep new relations of our previous (algebraic) with geometry, in particular the geometry of moduli spaces. This article is nearly finished and soon to be submitted for publication. Moreover, discussions with mathematicians at the Berkeley meeting led me to begin work on two more important questions. A brief review of these questions and the subject in general is as follows.

In 1991, Drinfel'd published a paper on quasi-Hopf algebras in which he defined a group now known as GT. He and Ihara showed that the absolute Galois group, a central object in the study of number theory, is contained in GT – it is conjectured to be equal

to it. It is of fundamental importance to number theory and Galois theory to understand the Galois group, which to this day remains mysterious to mathematicians, who have not yet been able to determine its structure.

Because the definition of GT is so essentially different from that of the Galois group, and yet the two are closely related and perhaps equal, I decided to attack some of the major conjectures concerning the Galois group, but replacing that group by GT, in order to see if they might not be more accessible in this case. Here are the three examples I have been studying this year.

1) Grothendieck conjectured that the absolute Galois group could be identified with the automorphism group of a tower (called the Teichmüller tower) of fundamental groupoids of moduli spaces of Riemann surfaces with n marked points. This year in the joint article with P. Lochak, we showed that GT is indeed the group of automorphisms of a properly defined tower associated to moduli spaces of Riemann surfaces of genus 0. We hope to generalize this result to a tower of moduli spaces in all genera.

2) Dessins d'enfants (children's drawings) are combinatorial objects which are used to study the set of algebraic curves defined over $\overline{BbbQ}$. They are interesting because via the correspondence between them and these curves, there is a natural action of the absolute Galois on them. It is a long-standing open question to define the Galois orbits of these curves via a set of simple invariants. Now, the group GT actually also acts on the set of dessins; therefore, in the spirit of the above philosophy, I am trying to identify the GT orbits rather than the Galois orbits of the dessins via a set of invariants.

3) Working on Teichmüller spaces, Robert Penner has defined a certain group called the universal Ptolemy group, which acts on the set of tesselations of the Poincaré disk. This group is deeply related to the absolute Galois group. It is thus interesting to attempt to uncover its relations with the Grothendieck-Teichmüller group. It would seem from a preliminary investigation of the question that GT acts as an automorphism group of the profinite completion of the Ptolemy group. This connection with GT would provide a new link between the Ptolemy group and the Teichmüller tower.

FINAL REPORT TO

OFFICE OF NAVAL RESEARCH

BY

LISA VAWTER

BUNTING INSTITUTE SCIENCE SCHOLAR

1993-1994

YEAR-END REPORT

Lisa Vawter

Summary of work for year 1993-1994

For the phylogenetic part of my project, I assembled a large insect database for the genes cytochrome oxidase subunit II and nuclear small subunit ribosomal RNA. I am currently performing multiple phylogenetic analyses on this database. This process has been underway for about four months and will take another three to four months to complete. I have agreed to present the results of these analyses in a symposium at Cornell University and to publish them in the volume resulting from that symposium. This portion of my project will give me an evolutionary tree for insect taxa, including termite and roach taxa. This evolutionary tree will serve as the base onto which I will superimpose the colony genetic information I am gathering for various termite taxa. The colony genetic portion of the project is currently unfunded, and thus idle. I expect that it will take approximately two funded years to complete.

For the colony genetic part of the project, I assembled large genomic libraries (>$5x10^5$pfu) in phage lambda ZapII for each of the taxa I proposed to study: *Reticulitermes flavipes, Cryptocercus punctulatus, Zootermopsis nevadensis,* and *Mastotermes darwinensis.* I prepared synthetic oligonucleotide trimer repeats for eight of the possible trimer repeats in the lab of Prof. Walter Gilbert. I screened the genomic DNAs of a wide range of insect taxa using dot hybridization to discern which trimers I should target in the various taxa and to determine whether evolutionary relationships predict which repeats have the highest copy number in a species. This gave the interesting and unexpected finding that even membership in the same genus has no predictive value as to which trimers would be most numerous in a genome.

Such extremely volatile spread and disappearance of trimers in evolutionary time is an unexpected and potentially fundamental medical genetic finding. It implies that the copy number of trimers in the genome can change quite rapidly. Information about the evolution and spread of these elements in populations is of urgent interest to the medical community because of the recently-discovered role of trimers in genetically-based human diseases (e.g. myotonic dystrophy, the fragile X-A syndrome, fragile X-E mental retardation, spinobulbar muscular atrophy, spinocerebellar ataxia type 1, hereditary dentatorubral-pallidoluysian atrophy, and Huntington's disease).

With the help of an undergraduate honors thesis student (minority male), I screened all four genomic libraries for the trimer repeats $[CAT]_n$ and $[GAG]_n$. I have isolated at least 200 trimer-repeat-containing phage clones from each of these libraries. These trimer repeats are the most variable portions of DNA fingerprinting alleles. With the help of two undergraduates (both women, one minority, funded by the Radcliffe Research Partners program), I subcloned (into pBluescript II) approximately 500 of the phage clones from *R. flavipes* and *Z. nevadensis.* I

have sequenced the pBluescript clones for *R. flavipes*. Among these clones were twelve that contained perfectly-repeated trimers and at least 25 nucleotides of clean sequence on either side of the repeat.

Using the sequence obtained for *R. flavipes*, I designed, using thermodynamic considerations, pairs of PCR (polymerase chain reaction) primers (synthetic oligonucleotides complementary to the sequences outside of the trimer repeat regions). After I synthesized and purified the PCR primers, I developed PCR conditions that allowed repeatable amplifications of the loci under consideration.

I then amplified the loci from DNA extracts from up to 5 termite individuals from each of 4 termite colonies to test for polymorphism in these putative hypervariable loci. I found between colony variation in all cases, but in no case found within colony variation. This is indicative of high levels of inbreeding within termite colony lineages. This is an interesting finding, as it implies that levels of inbreeding in colonies may be so high that the reproductives are essentially reproducing clonally, with the exception of the sex-determining loci. This finding suggests the following experiments:

(1) Isolate single locus fingerprinting loci that are repeating dimers (and should thus have a greater rate of change, even if this also makes convergent change more likely) and see if the lack of variation within colonies despite differences between colonies holds up.

(2) Isolate separate foraging groups from within colonies (use baiting in the field) and determine if widely disparate foraging groups are also apparently identical genetically. Geographically disparate foraging groups from a single colony would be expected to be the most likely groups of workers/soldiers to be least related to one another.

(3) Capture mating swarms from single colonies and see if they appear to be genetically identical.

(4) Capture mated pairs in the field and rear them in the lab to see which successfully produce offspring. Establish genetic identity of the parents by single locus fingerprinting of the DNA isolated from a leg. This method of sampling from a living insect and then allowing it to reproduce has been used in protein electrophoretic studies, but has yet to be applied to DNA fingerprinting studies.

It has been found (Traniello et al., 1994), in the genus *Zootermopsis*, that unrelated individuals may not be as successful at reproduction, but the method of measuring relationship in this study was indirect (not genetically based) and was thus not necessarily a good measure. Thus, direct genetic measures of relatedness are required to determine if this "outbreeding depression" holds.